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(54) Connection unit for peripheral devices

(57) A change-over switch (6) is disposed on a line of a peripheral device (1). The change-over switch is controlled by a control unit (5a) provided within a USB controller (5). When a host discontinues a polling operation to the peripheral device, the peripheral device first opens the circuit of the change-over switch so as to decrease the potential at a point of the host to substantially the same potential of a ground line (G). Then, the peripheral device closes the circuit of the change-over switch to increase the potential at the point to be close to a power supply voltage. Accordingly, the host determines that the peripheral device is reconnected to the host, and starts the polling operation.

FIG. 1A

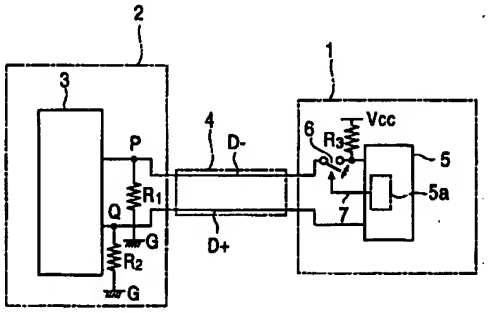
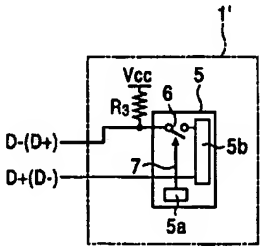


FIG. 1B



EP 1 085 422 A2

Description

[0001] The present invention generally relates to a connection unit for a peripheral device which is connected to a host by using, for example, a Universal Serial Bus (USB) interface. More particularly, the invention relates to a connection unit for a peripheral device provided with a function of automatically recovering the connection when an abnormality occurs in communications between the peripheral device and the host.

[0002] Fig. 5 is a block circuit diagram illustrating the connecting state between a conventional USB-compatible peripheral device (terminal) 10 and a host (computer unit) 2. Various types of devices, such as a keyboard, a mouse, a printer, a speaker, a game controller, etc., may be used as the peripheral device 10 to be connected to the host 2 via a USB.

[0003] The USB is formed of four lines, such as a pair of data lines (D+ line and D- line), a power line (Vcc), and a ground line (G).

[0004] As shown in Fig. 5, a USB port 3 is provided in the host 2, and a USB controller 11 is provided in the peripheral device 10. The USB controller 11 is connected to the USB port 3 via a USB-compatible cable 4.

[0005] The data line D- line of the USB port 3 is connected to one end of a pull-down resistor R_1, while the data line D+ line of the USB port 3 is connected to one end of a pull-down resistor R_2. The other ends of the pull-down resistors R_1 and R_2 are connected to ground lines G.

[0006] In the peripheral device 10, one end of a pull-up resistor R_3 is connected to the D- line and the other end is connected to the power line (Vcc).

[0007] With this configuration, when the peripheral device 10 is not connected to the host 2, the potential at a point P in Fig. 5 is 0 volts (low state). When the peripheral device 10 is connected to the host 2, the D- line, the D+ line, the power line Vcc, and a ground line of the peripheral device 10 are connected to the counterparts of the host 2, and the potential at the point P is increased (high state). When the host 2 identifies such a potential increase, it is determined that the peripheral device 10 is connected to the host 2. Simultaneously, the host 2 starts to perform a polling operation by calling the peripheral device 10 at regular intervals so that mutual communications are established between the host 2 and the peripheral device 10. During the polling operation, upon receiving a calling signal from the host 2, the peripheral device 10 returns a signal to the host 2 in response to the calling signal regardless of whether the peripheral device 10 is operated.

[0008] When the cable 4 is disconnected to remove the peripheral device 10 from the host 2, the point P is connected to the ground line G and decreases to 0 volts. A potential drop is detected in the host 2, and thus, the host 2 determines that the peripheral device 10 is disconnected.

[0009] In this manner, by monitoring whether the potential at the point P is in the high state or the low state, the host 2 is able to determine whether the peripheral device 10 is connected or disconnected.

[0010] If, however, there is no answer from the peripheral device 10 in response to three consecutive calls (polling) by the host 2, the host 2 discontinues the polling to the peripheral device 10, thereby interrupting the communications between the host 2 and the peripheral device 10. In order to recover the interrupted communications, the cable 4 of the peripheral device 10 must first be disconnected from the USB port 3 so that the potential at the point P drops to a ground potential (low state), and the cable 4 must then be re-inserted into the USB port 3 so that the potential is again raised to the high state. Alternatively, an operating system loaded in the host 2 must be restarted.

[0011] On the other hand, the peripheral device 10 possesses a resetting (initializing) function. For example, when a malfunction occurs in the peripheral device 10, such as a voltage change, the departure of processing from a fixed program routine, or a memory malfunction, the peripheral device 10 automatically detects such a malfunction and performs a resetting operation. If there is no answer from the peripheral device 10 in response to the polling by the host 2 a predetermined number of times and communications therebetween are interrupted during the occurrence of the above-described malfunction, the peripheral device 10 accordingly performs the resetting operation to recover itself. When, in spite of the resetting operation by the peripheral device 10, a signal cannot be transmitted from the peripheral device 10 to the host 2, as discussed above, it is necessary to remove the cable 4 from the USB port 3 and re-insert it to the USB port 3, or the system must be restarted.

[0012] Accordingly, in order to solve the above-described problems, it is an object of the present invention to provide a connection unit for a peripheral device which automatically recovers interrupted communications between the peripheral device and a host without the need for a user to restart a system or remove and insert a cable.

[0013] In order to achieve the above object, according to the present invention, there is provided a connection unit for a peripheral device which is connected to a host via a data line. The data line is set at a predetermined potential (high state) when communications are performed between the peripheral device and the host. The connection unit includes a recovering unit for establishing an apparently reconnected state between the peripheral device and the host by decreasing the potential of the data line (low state) from the predetermined potential when the communications between the peripheral device and the host are disabled and then by increasing the potential of the data line (high state) to the predetermined potential.

[0014] According to the aforementioned recovering unit, even if communications between the peripheral

device and the host (polling from the host to the peripheral device) are interrupted, they can be apparently reconnected without the need for physically disconnecting them, thereby automatically recovering the normal communication state. This eliminates the need for the operator to remove and reinsert a cable between the peripheral device and the host or to restart the system.

[0015] In the aforementioned connection unit, the data line may be connected to a ground via a first resistor in the host and may be connected to a power supply via a second resistor in the peripheral device. The recovering unit may establish the apparently reconnected state between the peripheral device and the host by setting the data line to the low state in the peripheral device and then by resetting the data line to the high state.

[0016] In the above-described connecting unit, the data line may include a D- line and a D+ line, and the recovering unit may establish the apparently reconnected state between the peripheral device and the host by setting at least one of the D- line and the D+ line to the low state in the peripheral device and then by resetting the data line to the high state.

[0017] For example, a switch for controlling the current flow may be disposed as the recovering unit on at least one of the D- line or the D+ line of the peripheral device. When the peripheral device detects the interruption of the calling from the host or detects a malfunction occurring in the peripheral device, the switch is controlled to apparently disconnect the D- line or the D+ line between the peripheral device and the host. This decreases the potential of the D- line or the D+ line provided with the second resistor to the ground potential, and the host determines that the peripheral device is disconnected though it is not physically removed. The peripheral device then resets the switch to the state before the data line is apparently disconnected, thereby increasing the potential of the D- line or the D+ line. The host then determines that the peripheral device is reconnected.

[0018] In the above-described connecting unit, the recovering unit may establish the apparently reconnected state between the peripheral device and the host by connecting the data line to a ground or causing a portion between the data line and the power supply to become a high impedance to set the portion to the low state and then resetting the portion to the high state.

[0019] For example, in setting the data line to the low state, the data line may be directly grounded, or the second resistor between the data line and the power supply may be grounded. Alternatively, the data line may be temporarily opened, or the portion between the second resistor and the power supply may be opened, thereby causing it to become a high impedance. In this case, advantages similar to those exhibited by the above case may be obtained.

[0020] In the aforementioned connecting unit, the host may regularly call the peripheral device via the data line, and the recovering unit may establish the apparently reconnected state between the peripheral device and the host when there is no answer from the peripheral device in response to calling by the host a predetermined number of consecutive times.

[0021] In the recovering unit, the aforementioned predetermined number of consecutive times of calling is determined by the specifications, and the recovering unit is operated when the peripheral device determines that the host is not calling.

[0022] In the above-described connecting unit, the recovering unit may establish the apparently reconnected state between the peripheral device and the host when detecting that one of the cases of a voltage change, departure of processing from a fixed program routine, and a memory malfunction occurs in the peripheral device. The recovering unit may be operated not only when one of the above-described malfunction occurs in the peripheral device, but also when the calling to the peripheral device is interrupted due to a malfunction occurring in the host.

[0023] Embodiments of the present invention, will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

Fig. 1A is a circuit diagram illustrating a connecting unit for a peripheral device according to a first embodiment of the present invention;

Fig. 1B is a circuit diagram illustrating a peripheral device according to a second embodiment of the present invention;

Fig. 2A is a circuit diagram illustrating a connecting unit for a peripheral device according to a third embodiment of the present invention;

Fig. 2B is a circuit diagram illustrating a peripheral device according to a fourth embodiment of the present invention;

Fig. 3 is a circuit diagram illustrating a connecting unit for a peripheral device according to a fifth embodiment of the present invention;

Fig. 4 is a circuit diagram illustrating a peripheral device according to a sixth embodiment of the present invention; and

Fig. 5 is a circuit diagram illustrating a conventional connecting unit for a peripheral device.

[0024] In the following description, a personal computer is provided as a host, while a device (such as a keyboard or a mouse) loaded with a USB interface is provided as a peripheral device.

[0025] Reference is first made to Fig. 1A in which a connecting unit for a peripheral device according to a first embodiment of the present invention is shown. A peripheral device 1 shown in Fig. 1A has a built-in USB controller 5 which is provided with a pair of data lines (D+ line and D-line). According to the USB interface system, communications are performed by using a pair

of signal lines (D+ line and D- line), and a positive potential and a negative potential, which are inverted with each other, are supplied to the two signal lines (D+ line and D- line), respectively.

[0026] A second resistor R_3 (hereinafter referred to as the pull-up resistor R_3) is connected at one end to the D- line within the peripheral device 1. The other end of the pull-up resistor R_3 is connected to a power line (Vcc).

[0027] A change-over switch 6 is also provided for the D- line. A control unit 5a is disposed within the USB controller 5 so as to control the change-over switch 6 to be on or off via a control line 7. The change-over switch 6 is normally closed. The D- line and the D+ line are connected to an interface circuit (not shown).

[0028] As in the case of the host 2 shown in Fig. 5, a host 2 shown in Fig. 1A has a built-in USB port 3. The USB port 3 is provided with terminals formed of a pair of data lines (D+ line and D- line), a power line (not shown), and a ground line G. One end of a first resistor R_1 (hereinafter referred to as the pull-down resistor R_1) is connected to the D- line of the host 2, and the other end is connected to the ground line G. One end of another first resistor R_2 (hereinafter referred to as the pull-down resistor R_2) is connected to the D+ line of the host 2, and the other end is connected to the ground line G.

[0029] When the peripheral device 1 and the host 2 are connected via a cable 4, the power line Vcc of the peripheral device 1 is connected to the power line of the host 2, so that the peripheral device 1 is able to receive power from the host 2. A ground line (not shown) of the peripheral device 1 is connected to the ground line G of the host 2.

[0030] When the peripheral device 1 is not connected to the host 2, a point P of the D- line shown in Fig. 1A is substantially at the same potential as that of the ground line G (ground potential, i.e., substantially 0 volts) (low state). When the peripheral device 1 is connected to the host 2, the D+ line and the D- line of the peripheral device 1 are connected to the counterparts of the host 2, and as a result, the potential at the point P of the D- line is raised to a predetermined voltage (high state), which is different from the ground potential.

[0031] USB-compatible peripheral devices operate in a high speed mode (12 Mbits/s) or a low speed mode (1.5 Mbits/s) according to the specifications. It is determined in which mode the peripheral device is operated according to the type of peripheral device. That is, in the low-speed-mode peripheral devices, a pull-up resistor is provided for the D- line, while in the high-speed-mode peripheral devices, a pull-up resistor is provided for the D+ line. Accordingly, when a low-speed-mode peripheral device is connected to the host 2, lines are formed by the power line Vcc, the pull-up resistor R_3, the pull-down resistor R_1, and the ground line G. When the current flowing in the lines is indicated by I, the potential generated at the point P can be expressed by $(R_1/(R_1 + R_3)) \times I$ (see Figs. 1 and 2). Conversely, when a high-speed-mode peripheral device is connected to the host 2, as shown in Fig. 3, lines are formed by the power line Vcc, a pull-up resistor R_4, the pull-down resistor R_2, and the ground line G. When the current flowing in the lines is indicated by I, the potential generated at a point Q shown in Fig. 3 can be expressed by $(R_2/(R_2 + R_4)) \times I$.

[0032] As stated above, the change-over switch 6 is controlled to be on or off by the control unit 5a disposed within the USB controller 5 via the control line 7. The change-over switch 6 may be formed by a regular transistor, such as a junction transistor of a field effect transistor (FET). The on/off control operation by the control unit 5a on the change-over switch 6 is discussed below by taking the peripheral device 1 and the host 2 shown in Fig. 1A as an example. In the normal state, a signal having a potential exceeding a predetermined potential (high signal) is input from the control unit 5a to the change-over switch 6 via the control line 7, thereby maintaining the change-over switch 6 in the open state. When a signal having a potential not greater than the predetermined potential (low signal) is input from the control unit 5a to the change-over switch 6 via the control line 7, the change-over switch 6 is closed. Conversely, the change-over switch 6 may be opened when a signal having a potential not greater than the predetermined potential is input, and may be closed when a signal having a potential exceeding the predetermined potential is input.

[0033] When the peripheral device 1 is connected, the host 2 performs a polling operation by calling the peripheral device 1 at regular intervals. If there is no answer in response to, for example, three consecutive calls, the host 2 discontinues the polling operation. The polling may be discontinued when malfunctions occur, such as a voltage increasing over a permissible level, the departure of processing from a fixed program routine, and a memory malfunction.

[0034] The peripheral device 1 possesses a resetting (initializing) function. Upon detecting the above-described abnormality, the peripheral device 1 automatically performs the resetting operation. During the resetting operation, the polling operation is discontinued. If, however, the peripheral device 1 detects the occurrence of a malfunction and immediately resets itself while the host 2 is calling the peripheral device 1 three consecutive times, the polling may not be discontinued.

[0035] When the peripheral device 1 identifies the discontinuation of the polling, the change-over switch 6 is changed. As stated above, the change-over switch 6 is normally opened, and when a signal having a potential exceeding the predetermined potential is input from the control unit 5a via the control line 7, the circuit of the change-over switch 6 is opened. Accordingly, the D- line becomes a high impedance, and the potential at the point P is fixed at a potential substantially equal to the ground line G (ground potential) (low state). As a result,

the host 2 detects the low potential of the point P and determines that the peripheral device 1 is disconnected from the host 2. In the peripheral device 1, a signal having a potential not greater than the predetermined potential is input from the control unit 5a to the change-over switch 6 via the control line 7, whereby the circuit of the change-over switch 6 is closed. Then, the potential at the point P is fixed at, for example, a predetermined power supply voltage (high state), and the host 2 identifies that the peripheral device 1 is connected.

[0036] As discussed above, the host 2 and the peripheral device 1 are apparently re-connected so that the polling operation can be restarted, thereby enabling the peripheral device 1 to send data.

[0037] A peripheral device 1' constructed in accordance with a second embodiment of the present invention is shown in Fig. 1B. In the peripheral device 1', the change-over switch 6, which is disposed outside the USB controller 5 in Fig. 1A, is provided within the USB controller 5. In Fig. 1B. the D-line and the D+ line are connected to an interface circuit 5b, and the change-over switch 6 is controlled to be on or off by the control unit 5a via the control line 7. The D-line and the D+ line may be located opposite to those discussed above.

[0038] By opening the change-over switch 6, the D- line (or D+ line) is changed to a high impedance and is thus set in the low state. The change-over switch 6 is changed from the low state to the high state in a manner similar to the switching operation discussed above.

[0039] A peripheral device 20 constructed in accordance with a third embodiment of the present invention is shown in Fig. 2A. The peripheral device 20 is provided with a line 8 on the D- line which is connected to a ground line G3 (which is to be connected to the ground line G of the host 2), and a change-over switch 26 is disposed in the line 8. The change-over switch 26, as in the change-over switch 6, is formed of a regular transistor, and is controlled by a control unit 25a disposed within a USB controller 25 via a control line 27. It should be noted that the change-over switch 26 is opened in the normal state. The portions other than the above-described elements are similar to those of the first embodiment shown in Fig. 1A and are designated by like reference numerals. An explanation thereof will thus be omitted.

[0040] If the polling operation performed by the host 2 is discontinued due to the occurrence of the above-described malfunctions while the peripheral device 20 is connected to the host 2, the circuit of the change-over switch 26 is closed by the control unit 25a via the control line 27. That is, a signal having a potential not greater than a predetermined potential is input from the control unit 25a, and the change-over switch 26 is closed. Accordingly, the power supplied from the power line Vcc entirely flows into the ground line G3 via the line 8 rather than flowing into the host 2. Thus, the potential at the point P is set to be substantially the ground potential of the ground line G (low state), and the host 2 determines that the peripheral device 20 is disconnected. Thereafter, a signal having a potential exceeding the predetermined potential is supplied from the control unit 25a to the change-over switch 26 via the control line 27, thereby opening the change-over switch 26. Thus, the potential at the point P on the D- line is raised to a predetermined power supply voltage (high state), and the host 2 determines that the peripheral device 20 is connected.

[0041] In the peripheral device 20, a circuit consisting of the ground line G3 and the change-over switch 26 may be formed within the USB controller 25, and the change-over switch 26 may be controlled by the control unit 25a.

[0042] A peripheral device 20' constructed in accordance with a fourth embodiment of the present invention is shown in Fig. 2B. In the peripheral device 20', the change-over switch 26, the pull-up resistor R_3, and the power line Vcc, which are disposed outside the USB controller 25 in Fig. 2A, are disposed within the USB controller 25. In Fig. 2B, the D-line and the D+ line are connected to an interface circuit 25b, and the change-over switch 26 is controlled to be on or off by the control unit 25a via the control line 27. The D-line and the D+ line may be located opposite to those discussed above.

[0043] With this arrangement, the change-over switch 26 is closed so that the D- line (or D+ line) is connected to the ground and is set in the low state.

[0044] Fig. 3 illustrates a high-speed-mode peripheral device 30 constructed in accordance with a fifth embodiment of the present invention. According to the specifications of the peripheral device 30, one end of the pull-up resistor R_4 is connected to the D+ line, and the other end is connected to the power line Vcc. A change-over switch 36 is provided for the D+ line of the peripheral device 30, and is controlled to be on or off by a control unit 35a disposed within a USB controller 35 via a control line 37. In the normal state, the change-over switch 36 is closed. When it is determined that the polling operation is not performed by the host 2, the circuit of the change-over switch 36 is opened, and is then closed.

[0045] When the peripheral device 30 is connected to the host 2, the D+ line is connected to the power line Vcc via the pull-up resistor R_4. When the current is indicated by I, the potential at the point Q shown in Fig. 3 can be expressed by $(R_2/(R_2 + R_4)) \times I$, and is increased from the ground potential (low state). By detecting this increased potential, the host 2 determines that the peripheral device 30 is connected to the host 2.

[0046] The configuration of the peripheral device 30 is not restricted to the fifth embodiment shown in Fig. 3, and the change-over switch 36 may be disposed within the USB controller 35, as in the case of the peripheral device 1' shown in Fig. 1B, and may be controlled to be on or off by the control unit 35a via the control line 37. Alternatively, a circuit consisting of the change-over

switch 36, the pull-up resistor R_4, and the power line Vcc may be formed within the USB controller 35, as in the case of the peripheral device 20' shown in Fig. 2B, and the change-over switch 36 may be controlled to be on or off by the control unit 35a.

[0047] Fig. 4 illustrates a peripheral device 40 constructed in accordance with a sixth embodiment of the present invention. In the peripheral device 40, a change-over switch 46 is provided between the power line Vcc and the pull-up resistor R_3. The change-over switch 46 is opened to disconnect the power line Vcc and the pull-up resistor R_3. Thus, the portion between the D- line (or D+ line) and the power line Vcc becomes a high impedance and is set in the low state. Alternatively, the pull-up resistor R_3 may be connected to the ground G, whereby the D- line (or D+ line) is set in the low state.

[0048] More specifically, the change-over switch 46 can be selectively changed among three states, as illustrated in Fig. 4: a connecting state between the power line Vcc and the pull-up resistor R_3 (state a), an open state between the power line Vcc and the pull-up resistor R_3 (state b), and a connecting state (state c) between the pull-up resistor R_3 and the ground line G.

[0049] When the change-over switch 46 is changed to the state b by a control unit 45a disposed within a USB controller 45 via a control line 47, the portion between the power line Vcc and the D- line (or D+ line) (data line) becomes a high impedance and is set in the low state. Then, when the change-over switch 46 is changed to the state c, the pull-up resistor R_3 is connected to the ground G so that the D- line is set at the ground potential and is thus set in the low state. Accordingly, the host 2 identifies that the peripheral device 40 is disconnected.

[0050] It is not essential that the change-over switch 46 be changeable among the three states, and it may be changed between the state a and state b or between the state a and the state c.

[0051] In the change-over switch 46, as in the case of the peripheral devices 1' and 20' illustrated in Figs. 1B and 2B, respectively, a circuit consisting of the pull-up resistor R_3, the change-over switch 46, the power line Vcc, and the ground G may be formed within the USB controller 45.

[0052] In the aforementioned peripheral devices 1, 1', 20. 20', 30, and 40, the control units 5a, 25a, 35a, and 45a may be disposed outside the USB controllers 5, 25, 35, and 45, respectively, and control the change-over switches 6, 26, 36, and 46, respectively.

[0053] The configuration of the present invention is not limited to the foregoing embodiments as long as the potential at the point P or the point Q on the data line can be switched between the high state and the low state. For example, the D- line and the D+ line may be short-circuited, or the change-over switch may be provided for a host.

Claims

1. A connection unit for a peripheral device which is connected to a host via a data line, said data line being set at a predetermined potential (high state) when communications are performed between said peripheral device and said host, said connection unit comprising recovering means for establishing an apparently reconnected state between said peripheral device and said host by decreasing the potential of said data line (low state) from the predetermined potential when the communications between said peripheral device and said host are disabled and then by increasing the potential of said data line (high state) to the predetermined potential.

2. A connection unit according to claim 1, wherein said data line is connected to a ground via a first resistor in said host and is connected to a power supply via a second resistor in said peripheral device, and said recovering means establishes the apparently reconnected state between said peripheral device and said host by setting said data line to the low state in said peripheral device and then by resetting said data line to the high state.

3. A connecting unit according to claim 2, wherein said data line comprises a D- line and a D+ line, and said recovering means establishes the apparently reconnected state between said peripheral device and said host by setting at least one of the D- line and the D+ line to the low state in said peripheral device and then by resetting said data line to the high state.

4. A connecting unit according to claim 1, wherein said recovering means establishes the apparently reconnected state between said peripheral device and said host by performing one of connecting said data line to a ground and causing a portion between said data line and said power supply to become a high impedance to set the portion to the low state and then resetting the portion to the high state.

5. A connecting unit according to claim 1, wherein said host regularly calls said peripheral device via said data line, and said recovering means establishes the apparently reconnected state between said peripheral device and said host when there is no answer from said peripheral device in response to calling by said host a predetermined number of consecutive times.

6. A connecting unit according to claim 1, wherein said recovering means establishes the apparently reconnected state between said peripheral device

and said host when detecting that one of the cases of a voltage change, departure of processing from a fixed program routine, and a memory malfunction occurs in said peripheral device.

FIG. 1A

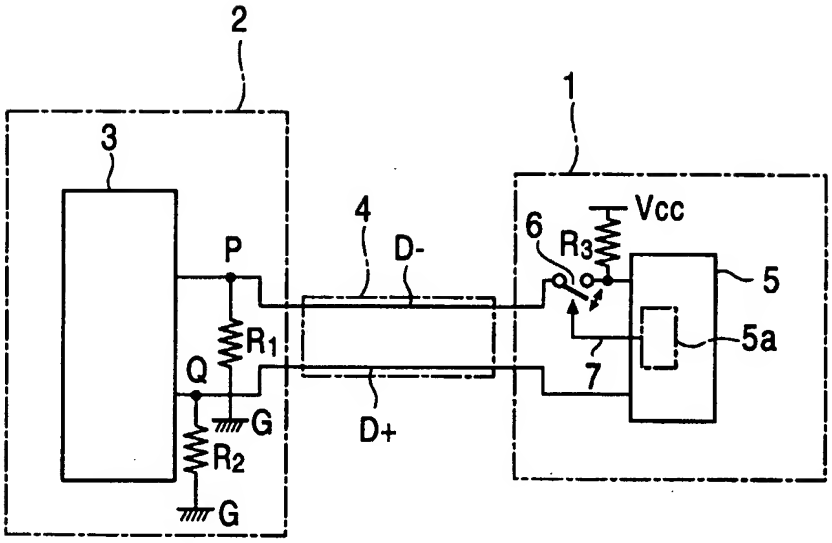


FIG. 1B

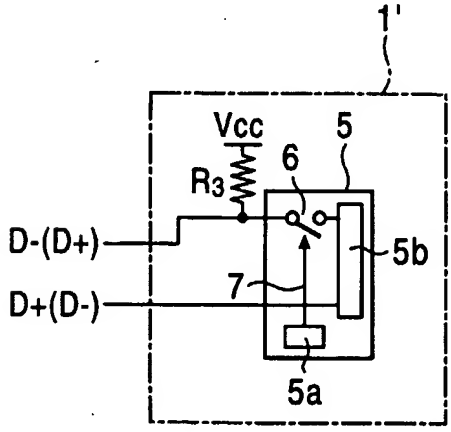


FIG. 2A

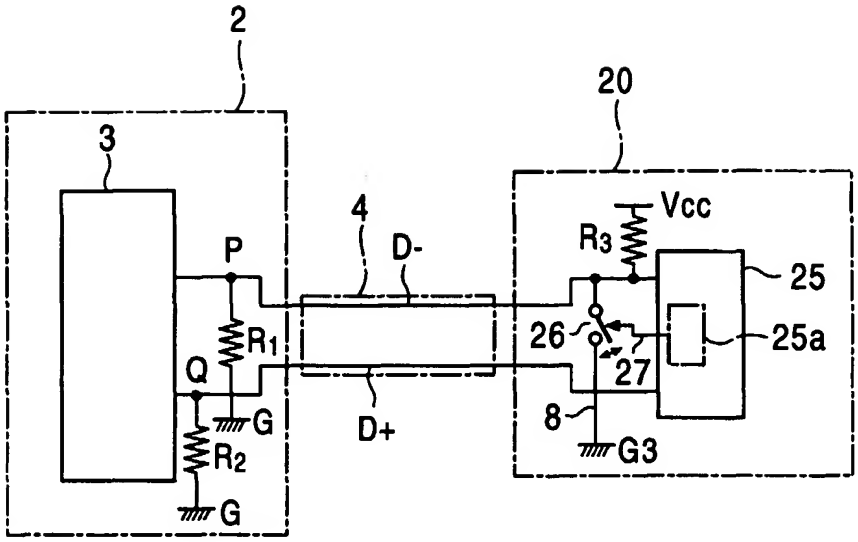

2
3
P
Q
R1
R2
G
G
4
D-
D+
20
Vcc
R3
25
26
27
25a
8
G3

FIG. 2B

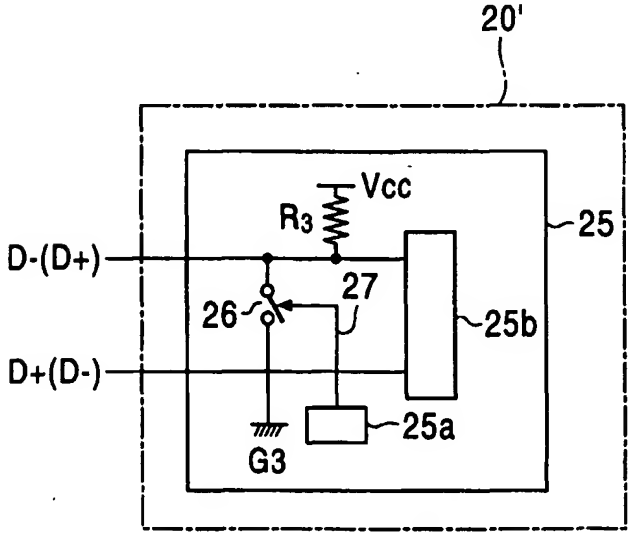

20'
Vcc
R3
25
D-(D+)
D+(D-)
26
27
25b
25a
G3

FIG. 3

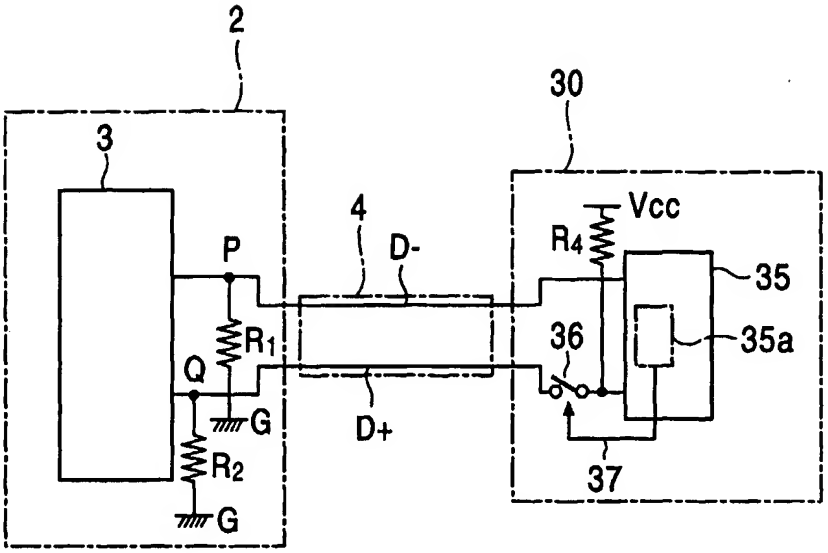

2
3
P
Q
R1
R2
G
G
4
D-
D+
30
Vcc
R4
35
35a
36
37

FIG. 4

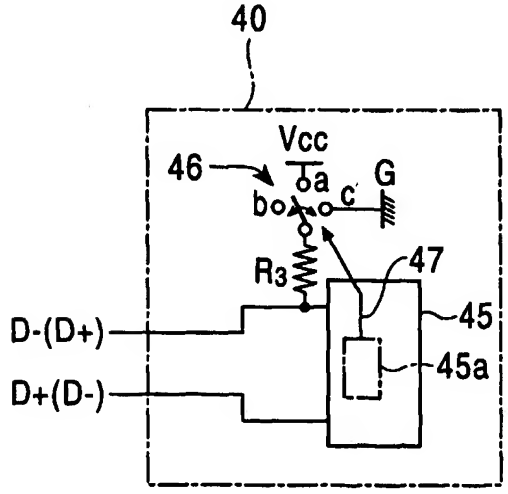

40
Vcc
46
a
b
c
G
R3
47
45
45a
D-(D+)
D+(D-)

FIG. 5
PRIOR ART